ewer broken windshields and higher early chip retention for chip seal coats.

Longer lasting pavement preservation surface treatments.

Return to full traffic speed in less than an hour.

Lower cost surfaces for very high traffic volume roads.

They’re all among the attributes of polymer modified asphalt emulsions. Experience has led maintenance and preservation engineers to believe that polymer modified asphalt emulsions give better short- and long-term performance than conventional emulsions.

But when the Federal Lands Highway (FLH) Division of the Federal Highway Administration (FHWA) wanted to provide guidance for its engineers, it found there is no definitive guide for selecting, specifying and using polymer modified emulsions.

In response, FLH sponsored a project to develop such a guide in conjunction with FHWA’s Office of Asset Management. Larry Galehouse and the National Center for Pavement Preservation (NCPP) were contracted for the project. Gayle King, of GHK, Inc., was the sub-consultant contracted to provide industry and material testing expertise.

The resulting product, *Polymer Modified Asphalt Emulsions: Composition, Uses and Specifications for Surface Treatments*, includes knowledge gathering, field trials, data collection, recommendations and first steps in developing performance specifications for emulsions.

**New Guidance Aids Understanding of Polymer Modified Emulsions**

By Mike Voth and Jim Sorenson
KNOWLEDGE GATHERING

The investigators did a comprehensive literature survey on the subject and consulted other researchers working on related, as yet, unpublished projects. Representatives from federal and local agencies, suppliers and academics pooled their best-practice experiences via face-to-face gatherings, teleconferences, an online survey and interactive presentations with an “alphabet soup” of organizations.

These included the three founding member associations of the Foundation for Pavement Preservation: the Asphalt Emulsion Manufacturers Association (AEMA), the Asphalt Recycling and Reclaiming Association (ARRA) and the International Slurry Seal Association (ISSA). It also included the Transportation Research Board (TRB), FHWA Expert Task Groups and FP² itself.

The project’s final report gives a comprehensive discussion of previous, present and future work on polymer emulsions. In addition to GHK, Inc., and NCPP representatives, technologists from PRI Asphalt Technologies, BASF Corporation, Paragon Technical Services, Inc., Kraton Polymers U.S., LLC, and SemMaterials, LLC, offered their time and expertise in shepherding the project.

WHAT ARE POLYMER MODIFIED ASPHALT EMULSIONS?

Asphalt emulsions (emulsified asphalts) are composed of asphalt particles suspended in water by use of a colloid mill, which shears the liquid asphalt in water. An added surfactant — a surface-active agent — stabilizes the suspension.

Emulsification of the very viscous asphalt allows it to be easily pumped, transported and applied at low temperatures, making emulsions ideal for use at remote locations while saving energy and providing safe worker conditions. Some engineers feel they are more eco-friendly than hot mix asphalt, hot asphalt cement or asphalt cutbacks. Asphalt emulsion application techniques, including chip seals, slurry seals, cape seals, cold recycling and cold mix, have been successfully used for over 50 years.

Polymers are very large molecules made by chemically reacting smaller molecules called monomers, which determine the polymer’s physical properties. Copolymers have two or more different monomers, with structures that may be random or may repeat in blocks of polymers (block copolymers).
Styrene-butadiene-styrene (SBS) is a block copolymer of blocks of polymerized styrene, polymerized butadiene and an additional styrene block. SBR (styrene-butadiene rubber) latex is a random polymer. The stretchy butadiene gives elasticity, and the styrene gives strength and compatibility with the asphalt. Polymers can be engineered to give the desired physical properties.

Manufacturers select polymers and asphalts to improve performance during storage, shipping, construction and end-use. SBR latex, SBS block copolymer and natural rubber latex (NRL) are the most commonly used polymers for emulsion paving applications.

SBR is generally manufactured as a water-based emulsion of polymer droplets suspended in water, and NRL, which is harvested from rubber trees, is also water-based. When used to modify asphalt emulsions, both SBR and NRL should be co-milled with the asphalt and water. SBS, a solid at room temperature, is generally pre-blended with the asphalt prior to emulsification. Polychloroprene latex (Neoprene) is another polymer used in one of the field trials.

Polymers are added at rates of 1 to 5 percent of the asphalt weight to all types of paving emulsions to improve performance. The exact percent polymer must be determined based on the base asphalt, the aggregate and the desired application and performance. This study found that specifying a random percent of polymer is not cost-effective and is undesirable.

Suppliers formulate rapid-setting emulsions with emulsifying agents developed to be stable in heated storage, but to separate asphalt and water phases (break) immediately after spray application for early chip retention on chip seal surface treatments.

**PM EMULSIONS FOR CHIP SEALS**

Examples of polymer modified rapid-setting emulsions commonly used for chip seals include CRS-2P, CRS-2L, CRS-2LM (cationic rapid set) and HFRS-2P (high float rapid set), with “P” standing for any type of polymer and “LM” for latex modified. Nomenclature varies greatly depending upon the state agency or supplier. Federal, state and local agencies have used polymer modified emulsion chip seals for decades on all types of roads, from low ADT rural highways to heavily trafficked interstates.

Slurry seal emulsions may also be polymer modified and are formulated as either slow- or quick-setting with emulsifiers to prevent breaking until the emulsion has mixed with and fully coated the fine aggregate. Examples of polymer modified emulsions used for slurry systems include CQS-1hP, CQS-1hL (cationic quick set) and CSS-1hP (cationic slow set).

Micro surfacing is a high-performance slurry seal that, by definition, includes relatively high concentrations of polymer. Further, micro surfacing has additives to chemically break quickly after mixing and application, allowing traffic.
return in less than one hour as well as greater thicknesses for rut-filling. Cape seals are a slurry or micro surfacing placed over a new, large rock chip seal.

COST-EFFECTIVENESS AND RECOMMENDATIONS

The study found that costs vary widely across the United States, depending on such things as local asphalt supply and availability of quality contractors.

While modified emulsions typically cost 20 to 30 percent more than unmodified, the increase in total project cost (including aggregates, construction, mobilization, traffic control, striping, etc.) is somewhere between 4 and 10 percent. That means the polymer is paid for with just a few months longer service life.

Pavement life extension depends on the preexisting condition of the pavement before treatment, as well as climate, traffic, materials, construction workmanship and maintenance practices. A good pavement management system can determine life cycle costs for various alternatives.

Because of their longer life, PMEs typically are justified for chip seals at traffic levels greater than 1,000 ADT. There are other advantages of PMEs that cannot be directly calculated from hard pavement management data. Issues such as fewer broken windshields, shorter traffic delays, faster construction, fewer loose chips and a better public perception of the finished product all factor into decisions to extend the use of PME to roads with less than 1,000 ADT.

Federal Land Highway project mobilization costs are relatively high; many roads in a park will be sealed at the same time; and the construction season coincides with the busiest travel season. The overall analysis of calculable economic savings and perceived user benefits led to this project’s conclusion that all emulsions used for FLH surface treatment projects should be polymer modified.

Further, the project recommends use of polymer modified slurry seals for pavements with less than 1,000 ADT and micro surfacing for pavements with higher than 1,000 ADT, for pavements where user delay is a concern and for pavements needing rut filling.

There are excellent guidelines for choosing the most effective preservation treatment for a given pavement at www.pavementpreservation.org/toolbox/guidelines.html.

Recent assessment of state highway departments by an NCPP/FHWA review team found that only 24 of 40 DOTs surveyed use polymer emulsions. Those agencies not using PMEs could stretch their funds and improve their roads with a sound pavement preservation program including polymer modified chip seals and other treatments.

SPECs FOR POLYMER MODIFIED EMULSIONS

This project found most industry experts agree there is a need for improved PME specifications, and most prefer to use performance-related test methods.

Current specifications do not adequately grade a PME or provide selection criteria for a given climate, traffic condition or performance expectation. By bringing together researchers working on this and related projects — at North Carolina State University; the University of Wisconsin; the University of Nevada at Reno; Colorado State University; Texas A&M; Texas DOT; Caltrans; the Asphalt Research Consortium; and the Western Research Institute — the newly formed Emulsion Task Force of FHWA’s Pavement Preservation Expert Task Group is currently working on draft specifications, with the goal of submitting a specification for AASHTO provisional approval by 2010.

To that end, samples from this study’s field projects were exhaustively tested using the dynamic shear rheometer (DSR) and other performance test methods to evaluate the proposed draft specifications and initiate a database of emulsion performance testing.

BASF, Paragon Technologies, PRI and SemMaterials all volunteered their expertise and testing services. Samples were also sent to researchers on the related projects. The test results will be compared with the performance of the pavements over time.

EVALUATION IN FIELD

To evaluate the collected findings of the project, including the parameters and practicality of the proposed test methods, FLH used several of its field projects in 2008 and 2009 as resources for material samples, cost data and performance evaluation.
The unusual price spikes and unavailability of petroleum-based materials in 2008 caused delays and prevented representative cost analysis. However, the field projects provided a good variety of climate conditions and polymer technologies.

Project site climates ranged from very hot and dry to cold and wet, as well as extreme temperature fluctuations. An 11-mile Neoprene modified asphalt emulsion chip seal was placed at Dinosaur National Monument, which spans the borders of Utah and Colorado. The “Utah Parks” project included 90 miles of CRS-2L chip seal and natural rubber modified microsurfacing at locations in Arches National Park, Canyonlands National Park, Natural Bridge National Monument, and Hovenweep National Monument. Death Valley National Park was the site of a 21-mile SBR latex modified asphalt chip seal. The last project planned for summer 2009 was a SBS-modified chip seal at Crater Lake National Park in Oregon.

The chip seals were fog sealed, providing enhanced chip retention, longer surface life (reducing oxidation) and a pleasing, black surface. The results of the laboratory testing of the samples taken from these projects will be compared with the performance over time of these pavements.

FHWA has published a Field Guide detailing the findings and recommendations from this project. Intended for FLH, county, municipal, state, local technical assistance program and other federal project development and maintenance practitioners, it is available from FHWA and the NCPP (www.pavementpreservation.org).

The full report on this project will be posted on that site this fall, and all of the data collected is currently there for the use of other researchers.

PERFORMANCE AND SPECIFICATIONS

Polymers improve performance during construction, immediately after construction and over time. Residues from polymer modified asphalt emulsions have been documented to be stiffer, more ductile, more adhesive, more cohesive, more elastic, less temperature-susceptible and generally more durable than unmodified asphalt.

The literature has numerous examples of improvements in resistance to rutting, cracking, shelling, windshield damage, flushing, moisture damage, oxidative aging and fatigue failure.

Of course, quality aggregates and best-practice construction are essential to optimal performance of any emulsion application. While current specifications do not fairly predict performance, we are confident that this project’s lab and field results will aid the Emulsion Task Force’s efforts in the timely adoption of performance specifications for asphalt emulsions.

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